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Abstract

This paper explores the empirical association between Internet use, e-government and corruption in a large panel of countries covering the 1998-2003 period. We show that higher numbers of internet users and higher levels of e-government are associated with significantly lower levels of corruption. Controlling for most variables used in previous work on corruption and addressing the endogeneity issue, results are shown to be robust and to carry economic significance. This leads us to conclude that well-designed ICT policies are likely to bring substantial benefits in the fight against corruption.

Keywords: Corruption, ICT, Internet, e-Government

JEL Classifications: D73, H11, O1, O57

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"Thanks to the [e-government] scheme, the government is cutting staff (through natural attrition, so far). But for Mr. Naidu [chief minister of Andhra Pradesh] and his admirers the main goals are "transparency, accountability and speediness", and to "reduce the interface" between government and citizenry. This puzzling phrase recognizes a sad truth: where public and government meet, corruption plays gooseberry. Not only do computers rarely solicit bribes but they make corruption more difficult [...]." (The Economist, March 20, 2003)

1 Introduction

The argument put forward in the present paper is that an increase in the use of information and communication technology (ICT) is likely to reduce corruption. We identify two main channels through which ICT affects corruption. The first channel is outlined in the passage above: ICT simply reduces the *interface* between government and citizenry. The second channel recognizes that ICT increases the amount of *information* in the economy, which in turn is likely to make the government more accountable. This second channel is related to recent work by *inter alia* Besley and Burgess (2001, 2002), Strömberg (2001, 2004) and Svensson and Reinikka (2003).

Wescott (2003) provides a long list of anecdotal evidence suggesting the importance of the interface channel. In Pakistan for instance the entire tax department is undergoing restructuring and ICT systems are being introduced with the purpose of reducing contact between tax collectors and tax payers. In the Philippines the Department of Budget and Management has established an on-line e-procurement system that allows public bidding for suppliers. This system has increased transparency in transactions. In South Korea the Online Procedures Enhancement for Civil Applications allows ordinary citizens to monitor applications for permits or approvals where corruption is most likely to take place; it also allows questions to be raised in case irregularities are detected. In the Indian state of Andhra Pradesh, where 40% of the 76 million people cannot read, 214 deed registration

offices have been fully computerized. Deeds are registered in one hour; other services like encumbrance certificates are accomplished in just 15 minutes. The process started in April 1998 and as of February 2000 about 700,000 documents had been registered. Before the introduction of online registration, the opaqueness of property valuation forced citizens to employ middlemen who used corrupt practices to obtain services. Several Asian countries are also introducing smart cards that help citizens to get health-care services without having to provide corruption-prone cash payments for these services.

Another interesting scheme (eSeva) has been implemented in Andhra Pradesh. At any of the eSeva centres, located around the state, there are a dozen counters where clerks at computer terminals assist the 600,000 households who visit monthly in completing any of a menu of 32 transactions with the government. Among other things, citizens can pay utility bills and register births and deaths at the centres (The Economist, March 20, 2003).

Perhaps the most impressive example of the potential of ICT in empowering citizens to challenge corrupt and arbitrary bureaucratic action is the Bhoomi (meaning land) system from the Karnataka state in India, where the introduction of an electronic land record system serving some 7 million farmers has saved clients some 1.32 million work days in waiting time and Rs. 806 million in bribes (World Bank, 2004).[1] The main function of the Bhoomi system is to maintain records of rights, tenancy and cultivation, which are crucial for transferring or inheriting land and obtaining loans. Under the old system some 9,000 village accountants, each serving three or four villages, maintained land records. Farmers had to seek out a village accountant in order to obtain a copy of the record or make changes. Accountants were not easily accessible and farmers faced long delays; two out of three paid bribes, and over two-thirds paid more than Rs. 100, compared to the official service fee of Rs. 2. Under the electronic Bhoomi system farmers can enter a Bhoomi kiosk and get these records or file

[1] See Chawla and Bhatnager (2004) for a case study of the Bhoomi system.

for changes in 5-30 minutes. Moreover, all requests are served on a first-come, first-served basis.[2]

The use of ICT by governments around the world is in fact surprisingly widespread. An influential United Nations (2002) report defines e-government as: "utilizing the Internet and the World-Wide-Web for delivering government information and services to citizens". The report introduces a five-step classification of stages of e-government: (i) *emerging*: a government Web presence is established through a few independent official sites, and information is limited, basic and static; (ii) *enhanced*: content and information is updated with greater regularity; (iii) *interactive*: users can download forms, contact officials, and make appointments and requests; (iv) *transactional*: users can pay for services or conduct financial transactions online; (v) *seamless*: complete integration of e-functions and services across administrative and departmental boundaries.[3]

According to the report, in 2001, 32 countries were classified as emerging; 64 were enhanced; 55 were classified as interactive; 17 were classified as transactional; no country was classified as seamless. This means that in 2001, 72 countries actually allowed its citizens to interact with the government via the Internet. India, Pakistan and the Philippines, for instance, were classified as interactive due to the presence of systems like the Bhoomi system, the online tax reporting system and the on-line e-procurement system, respectively.[4]

[2]Other examples include: Christal in Argentina, a Web site aiming at disseminating online information concerning the use of public funds; the Central Vigilance Commission Web site in India, where the public among other things can report information about wrongdoings of public servants; an on-line Customs Bureau system in the Philippines, which has lessened the cost of trade for businesses, reduced opportunities for fraud and boosted revenue collection of the Customs Bureau; and several computerized interstate check posts in Gujarat, India, which has significantly reduced corruption at check posts. See <http://www1.worldbank.org/publicsector/egov/anticorruption&t.htm> for more information on these and other initiatives.

[3]The e-government classification is based on an examination of over 1,900 UN member country Web sites.

[4]Interestingly, the report notes that 2001 saw a greater expansion in government online presence than in the previous five years combined. We should therefore expect that a substantial number of countries can be classified as interactive in 2003 (our dataset span 1998-2003). Moreover, Fink and Kenny (2003) argue that despite much talk of a widening absolute digital divide, poorer countries are actually closing the divide in

There is also an abundance of anecdotal evidence documenting the importance of the information channel. In a recent edition of the New York Times Pulitzer Prize winner Nicholas D. Kristof told the fascinating story of a Chinese investigative journalist, Li Xinde, who maintains an anti-corruption Web site, which targets official corruption in China (New York Times, May 24, 2005).[5] Mr. Li travels around China with a laptop and a digital camera, investigating cases of official wrongdoing. He then writes about them on his Web site and leaves town before the local authorities can arrest him. Recently Mr. Li was instrumental in exposing a corruption case involving the deputy mayor of Jining, a large Chinese city. Mr. Li's Web site published an investigative report and a series of photos showing the deputy mayor kneeling and crying, apparently begging not to be reported to the police. This caused a sensation and the deputy mayor was subsequently arrested. By confining the content of the site to factual exposures of corruption, never questioning the party's rule, the Web site is tolerated by the Communist Party. According to Kristof, the Li Xinde story shows that the Internet is beginning to play the watchdog role in China that the press plays in the West.

Another interesting example is the scam-busting Indian Web site Tehelka (meaning sensation in Hindi) <http:\\www.tehelka.com>, which has revealed corruption in defence deals and showing top officials accepting kickbacks. The Web site posted videotapes showing politicians, bureaucrats, military officers and middlemen seeking and taking bribes from arms dealers; the arms dealers were in fact Tehelka journalists (New York Times, February 13, 2003).

That the Internet is a powerful mass media is undisputed. To illustrate, consider the remarkable incident which took place in China recently. A brush with a tractor apparantly

relative terms.

[5] A blog (short for Web log) is a mix between a diary and a list of links to articles on the Web. Anyone surfing the Web can read them. Some are serious and informative; others are not. According to the Economist (July 4, 2002) there were half a million blogs in 2002. According to India Monitor (May 17, 2005) there are some 8 million blogs worldwide in 2005.

caused such rage in the mind of a wealthy Chinese that she decided to plough her car into a group of poor unemployed workers waiting for work on a street corner in a poor city north-east of Bejing. The incidence caused death and serious injury. The court ruling, giving the women a suspended sentence for killing two and injuring 12, triggered a massive outpouring of rage on the Internet. Soon after Chinese newspapers followed suit and eventually the government succumbed to the pressure and announced that the case would be re-examined (The Economist, January 29, 2004).

A similar incidence concerns a clash, in the village of Shengyou in Hebei Province, between peasants and hundreds of armed thugs sent by property developers to seize their land. A video smuggled out by one of the villagers shows his fellow residents being beaten with staves and shovels; shotguns fired by some of the thugs can also be heard. Six villagers were killed and around 50 were wounded. With copies of the video circulating on the Internet the authorities reacted promptly: a mayor and a Communist Party chief of the municipality to which the village belongs were sacked. The official media reported that 22 people had been arrested, including the bosses of a firm contracted by a local state-owned power plant to build a waste-processing plant on the village fields (The Economist, June 23, 2005).

New regulations in China now require owners of blogs to register with the government. The move is widely seen as an attempt to regulate blogging.[6] Yet only 430,000 bloggers have made themselves known to the Chinese Information Ministry, suggesting that most of the countries 4 million bloggers are choosing to stay "underground". This probably reflects that bloggers are betting on not getting caught (The Australian, June 06, 2005). By extension, it reflects the difficulties of regulating the Internet: despite strict censorship of the press Libya has not blocked the sites that regularly ridicule, question and insult the government;

[6]In fact, claiming to be acting in accordance with its principle of respecting local laws, Microsoft has agreed to block the words "democracy" and "freedom" on its new Internet portal in China (The Economist, June 17, 2005).

despite massive firewalls the Saudi authorities, having blocked over 400,000 Web sites, are not able to prevent al-Queda from communicating and spreading propaganda through the Internet; and in Syria, where lots of sites are banned, street vendors sell programmes that cover electronic trails on the Internet for just one dollar, allowing surfers to peek at the forbidden stuff (The Economist, July 8, 2004).[7]

Despite all these encouraging stories ICT may also open up new channels through which bribes can travel. The Economist (June 11, 2005) reported a story about a mother who was separated from her daughter by war in Congo (Democratic Republic). Following the peace accord the mother booked an aeroplane ticket for the daughter to rejoin her. As the girl was about to board the plane she was detained by an obstructive official. He was willing to let the girl board the plane for a bribe of US$ 20. Realizing that the little girl had no cash, the official made the mother send an equivalent of US$ 20 by mobile telephone: the mother simply had to "recharge" the official's mobile phone with prepaid airtime. It took minutes to send the bribe across the country, and since there is no proper banking system in Congo the transaction would not even have been possible without mobile phones.

To be sure, ICT eliminates many opportunities for corruption for those who do not understand the new technology well; at the same time, however, it introduces new rents to those who understand the new technology well enough to manipulate it. Whether on balance ICT reduces corruption is evidently an empirical question, and one which we entertain in this paper. In particular, we investigate the two channels identified above and ask whether countries with more ICT face less corruption? The answer is in the affirmative, and we therefore explore whether this statistical association can be considered to be causal, with

[7] In Canada, an Internet blog-site dubbed "Captains Quarter's" posted explosive details on a secret judicial commission in Montreal investigating a huge political corruption scandal. The Canadian press was banned from reporting on the commission hearings, but the blocker was able to ignore the ban by setting up a site on the U.S. side of the border (The Economist, April 7, 2004).

causality running from more ICT to less corruption.

The paper is structured as follows: Section 2 reviews the literature on the determinants of corruption with a special focus on mass media. Section 3 describes the data and discusses the empirical model. Section 4 presents results and Section 5 concludes. The Appendix reports robustness issues.

2 Selected Literature Review

2.1 Mass media

We are not familiar with any academic literature on the role of the interface channel. This is not so for the information channel. The Internet falls under the general classification of mass media and there is a nascent economic literature on the effects of mass media on the responsiveness of politicians and governance.[8]

Besley and Burgess (2002) propose a political agency cost model to focus on the role of the mass media in increasing political responsiveness. In their setup increased information enables vulnerable citizens to monitor the actions of opportunistic politicians and to use this in their voting decisions. That is, mass media enable voters to obtain information about the performance of politicians. Only a fraction of voters are vulnerable: they risk being hit by a shock, whose consequences can be mitigated by public action (effort). The incumbent politician derives positive utility from holding office and disutility from putting in effort. Provided that there is sufficient political competition the model predicts that effort by an incumbent politician is an increasing function of media access, voter turnout and the relative size of the group of vulnerable voters. Using Indian data covering the 1958-1992 period they

[8]The Internet is also used increasingly by editors and publishers of conventional media in developing countries. For instance, the Daily Graphic in Ghana and the People's Daily in China are published on a Web site (Wilson, 2004).

show that more responsive states (measured by how the individual states responded to food shortages via the public distribution of food) have higher electoral turnout, higher literacy and higher levels of newspaper circulation.

In a similar vein Strömberg (2004) studies radio's impact on public spending decisions. Using a voting model he shows that mass media help increase the information of voters and thereby influence government policies towards favouring areas with more informed voters. For a group of voters to defend their political interests they must cast a vote. Furthermore, voters must hold information with respect to what their elected representatives have done for them. If better informed citizens are more likely to vote, and if citizens with greater access to the media are more informed, then it is more costly for politicians to neglect voters with access to political information via the media. Testing the model on 2,500 US counties between 1920 and 1940, a period in which the radio gained huge popularity, he shows that data corroborates the predictions of the model. More resources were allocated to areas where a larger proportion of the population had radios. Moreover, areas with a larger share of literate people and with higher voter turnout were favoured in terms of relief funds.

Svensson and Reinikka (2003) analyze the value of increased information in a Ugandan setting. A survey of 250 government primary schools and 3 central government ministries was implemented in 1996 (covering the period 1991-1995). The objective of the survey was to measure the difference between intended resources (from the *central* government) and resources actually received (by the school). Svensson and Reinikka show that for every dollar spent on non-wage education items by the central government around 80 cents were captured by *local* government officials and politicians. As the extent of the local government capture became known the central government decided on a strategy of citizen empowerment. Data on monthly transfers were made available at the local level by publishing the information in national newspapers and their local language editions. This information campaign was

subsequently extended. Primary schools were mandated to post notices on actual receipts of funds for all to see. In effect, information on transfers by the central government was made public in newspapers while posted notices made it clear what had actually been received by the school. Importantly, there was a concurrent increase in the likelihood that officials caught embezzling public funds would be held accountable. A repeat survey carried out in 2002 was able to evaluate the effects of the information campaign. Interestingly, Svensson and Reinikka find large quantitative effects of improved access to public information.

Finally, Brunetti and Weder (2003) have studied the connection between mass media and corruption. Based on the hypothesis that a free press will raise the costs of extracting bribes by increasing the probability of being detected and punished, they analyze the empirical association between press freedom and corruption in a sample of countries during the 1994-1998 period. They report evidence of a significant relationship between more press freedom and less corruption.

2.2 Other determinants of corruption

Other papers have focused on different determinants of corruption. In what follows we outline some recent published contributions. In a very comprehensive study Treisman (2000), using different measures of corruption and a variety of possible determinants, finds that historical indicators such as protestant tradition and a history of British rule are at least as important in explaining the level of corruption as current policies. More specifically, being a former British colony, having a protestant tradition, having a longer-term uninterrupted democracy and being economically developed are robustly associated with less corruption. Due to the lack of suitable instruments the paper leaves out suggestions about the direction of causation.

Persson *et al.* (2003) analyze how electoral rules affect political corruption using a sample of democracies during the 1990-1998 period. They show that countries with smaller voting

districts tend to have more corruption. The mechanism driving this result may be that larger electoral districts lower barriers of entry for new candidates. This in turn increases political competition and hence reduces corruption. However, this result is not robust to the use of different specifications. A more robust finding in Persson *et al.* is that countries predominantly voting for individuals have less corruption than countries in which politicians are elected from party lists. The reason is that the latter reduces individual accountability.

Fisman and Gatti (2002) focus on the association between decentralization and corruption. Decentralization may help reduce corruption by making it easier to monitor bureaucrats. Yet decentralization can also lead to inefficiency in the provision of public services. Using a measure of decentralization, defined as the sub-national share of total government spending, and controlling for the possibility that larger countries have a lower ratio of public service outlets per capita, Fisman and Gatti report a robust negative relationship between decentralization in government expenditure and corruption. Moreover, using IV techniques they argue that causality runs from a higher degree of decentralization to lower levels of corruption.

Rijckeghem and Weder (2001) analyze the effect of wages in civil service on corruption. Low salaries may give public servants incentives to supplement their incomes by taking bribes. However, if wages are perceived as being fair it may be feasible to have low levels of corruption and low levels of remuneration. With a basic specification including the ratio of government wages to manufacturing wages they are able to find a robust negative relationship between relative civil-service pay and corruption.

Ades and Di Tella (1999) study the effects of competition on corruption. From a theoretical point of view more competition reduces the amount of rents bureaucrats can extract from firms. At the same time it becomes less valuable for society to avoid corruption, resulting in less control of bureaucrats. The effect of competition on corruption is therefore *a*

priori ambiguous. Ades and Di Tella (1999) show that in countries where firms earn more, corruption levels are also higher.

Finally, two studies focus on the effect of women in parliament on the level of corruption. Women are perceived as being more trust-worthy and public-spirited than men. A higher representation of women in parliament should therefore be associated with lower levels of corruption. Dollar *et al.* (2001) and Swamy *et al.* (2001) both report results in favour of this hypothesis.

3 Empirical Baseline Model

We are interested in estimating the following model:

$$CPI_{i,t} = \alpha + \beta \cdot INTERNET_{i,t-1} + \gamma \cdot eGOV_i + \phi \cdot GDPCAP_i + \delta \cdot PRESS_{i,t-1} + X_{i,t-1} \cdot \theta' + \varepsilon_{i,t} \quad (1)$$

The dependent variable, $CPI_{i,t}$, is the value of the Corruption Perception Index (CPI) from Transparency International (TI) for country i in year t. The index is constructed annually from a number of individual surveys of businessmen, the local population, and from ratings by economic risk analysts and country experts. The CPI score ranges between 10 (no corruption) and zero (endemic corruption). We use CPI data covering the 1998-2003 period.[9]

We rely on two ICT variables, viz. $INTERNET_{i,t-1}$ and $eGOV_i$. The Internet variable is the number of Internet users per 1,000 people and is taken from World Development Indicators (WDI) 2004. $INTERNET_{i,t-1}$ covers the 1997-2002 period, i.e. it is lagged one

[9] The CPI is highly correlated with the other frequently used corruption measures (see Treisman, 2000). In fact, the correlation between the graft measure of Kaufmann *et al.* (2005) and CPI is 0.974 in our sample. However, the graft measure is only available biannually. We note that the conclusions of the present paper also holds up with the graft measure.

period compared to CPI.[10] The e-government variable is a time-independent dummy variable, which takes the value one if a country is classified as either interactive or transactional in the United Nations (2002) report described in Section 1 (recall no country was classified as seamless). Hence, in all countries where $eGOV_i = 1$ Internet users could (in 2001) download forms, contact officials, and make appointments and requests. As argued in Section 1 the interface channel operates through the online presence of these services.[11]

As several of the papers referred to in Section 2 control for freedom of speech we include a measure of press freedom, $PRESS_{i,t-1}$, assembled by Freedom House. $PRESS_{i,t-1}$ ranges between zero (freedom) and 100 (no freedom).[12] We also include initial (1990 values) real GDP per capita, $GDPCAP_i$, to control for the overall social and economic development.[13]

$X_{i,t-1} \equiv [X^0_{t-1} : X^1_i : X^2_{i,t-1}]$ is a vector of predetermined regressors. X^0_{t-1} includes a time dummy and geographical dummies; X^1_i includes legal origin dummies and indices of ethnic, religious and linguistic fractionalization (all from Alesina *et al.,* 2003); X^2_{it-1} includes the government consumption expenditure share of GDP, the trade share of GDP, population size (log) (all from WDI, 2004) and the percentage of seats occupied by women in parliament (from the Women in Parliament database).[14]

[10] Subscript $t-1$ always means that the variable of interest is lagged one period compared to $CPI_{i,t}$, e.g. $INTERNET_{i,t-1}$; absence of subscribt $t-1$ means that the variable is constant over time, e.g. $eGOV_i$.

[11] The interface channel does not operate in environments classified as emerging or enhanced.

[12] We also used the Gastil index of civil liberties from Freedom House and the Polity IV democracy index provided by the Center for International Development and Conflict Management as proxies for freedom of speech. This did not change the qualitative results reported in the paper.

[13] We use initial real GDP per capita since GDP per capita is probably endogenous (Bardhan, 1997).

[14] We use the lower house if there are two chambers.

4 Results

4.1 OLS estimation

Table 1 shows the pooled OLS results.[15] All t-values are based on a fully robust variance estimator.[16] Column (1) provides OLS results for equation (1) with only the X^0_{t-1} part of $X_{i,t-1}$ included. The Internet variable has the expected positive sign and is significant at one percent: corruption is lower in countries with more Internet users. However, e-government is insignificant at conventional levels. Initial real GDP per capita is positive and significant at one percent: economically more developed countries experience less widespread corruption. The negative sign on press freedom corroborates the findings of Brunetti and Weder (2003) that countries with a free press experience less corruption. Interestingly, our basic specification explains 80 percent of the variation in CPI. Moreover, column (2) demonstrates that excluding OECD countries from the sample has little effect.

Several papers reviewed in Section 2 found that religious, linguistic and ethnic fractionalization and legal origin dummies are important (deep) determinants of the quality of governance. Columns (3) and (4) adds such controls, i.e. includes $[X^0_{t-1} : X^1_i]$. Results are robust with respect to the inclusion of these deep determinants.

In columns (5) and (6) we add additional controls. Small countries and decentralized countries are likely to experience less corruption (Fisman and Gatti, 2002); the former may be better at establishing a well-functioning administration, whereas politicians are probably more intensively monitored in the latter. We therefore include population size (log) and the total government expenditure share of GDP as indicators of size and decentralization,

[15] In this section we do not worry about orthogonality between explanatory variables and the error term. It is therefore worth recalling that OLS (assuming ergodic stationary) gives a consistent estimate of the least squares projection (the best linear predictor) (see Hayashi, 2000).

[16] The variance estimator is robust with respect to (arbitrary) heteroscedasticity and (arbitrary) serial correlation across time. We only require that observations are independent across countries.

Table 1: Pooled OLS estimates

	(1)	(2)	(3)	(4)	(5)	(6)
INTERNET	0.007***	0.008***	0.005***	0.007***	0.003***	0.007**
	(4.63)	(4.59)	(4.23)	(4.36)	(3.07)	(2.58)
eGOV	0.210	0.067	0.226	0.073	0.338	0.216
	(0.89)	(0.31)	(1.10)	(0.36)	(1.32)	(0.76)
GDPCAP	0.091***	0.188***	0.098***	0.152***	0.077***	0.100
	(3.77)	(3.68)	(5.03)	(2.90)	(6.37)	(1.53)
PRESS	−0.020**	−0.015***	−0.018***	−0.015***	−0.014**	−0.012
	(2.57)	(2.63)	(2.82)	(2.86)	(2.06)	(1.63)
Controls 1	No	No	Yes	Yes	Yes	Yes
Controls 2	No	No	No	No	Yes	Yes
Excluding OECD	No	Yes	No	Yes	No	Yes
Total observations	543	406	528	397	467	340
(No. of countries)	117	94	113	91	103	81
R-squared	0.80	0.63	0.85	0.67	0.89	0.65

Dependent variable: Corruption Perception Index (CPI) 1998 - 2003. OLS estimates; t-statistics, which are fully robust with respect to (arbitrary) heteroscedasticity and (arbitrary) serial correlation across time, are reported in parenthesis. *, **, *** indicate significance at 10%, 5% and 1%, respectively. All regressions include a constant term, time dummies and geographical dummies. Controls 1: legal origin dummies, indices of linguistic, religious and ethnic fractionalization; Controls 2: women in parliament, openness, population (log), and government expenditure share of GDP.

respectively. We also include openness, measured as imports plus exports as a share of GDP, to proxy market structure and the degree of competition (Ades and Di Tella, 1999). Finally we include the percentage of seats occupied by women in parliament: women are considered more honest than men and hence less likely to accept bribes (Dollar *et al.,* 2001; Swamy *et al.,* 2001). Consequently, all elements of $X_{i,t-1}$ are included in columns (5) and (6). Columns (5) and (6) show that the coefficient on $INTERNET_{i,t-1}$ remains significant at one and five percent, respectively. $eGOV_i$ remains insignificant in both columns. Press freedom and initial real GDP per capita turn insignificant in the sample where OECD countries have been excluded.

4.2 GMM and fixed effects estimation

According to an OECD report e-government became one of the six pillars of the Mexican Presidential Agenda for Good Governance in 2002. In fact, e-government is widely seen as a tool to improve transparency, quality and efficiency of government (OECD, 2005). This suggests that e-government may be a function of the level of corruption. Moreover, the number of Internet users may be a function of the level of e-government. As is well-known, in such cases OLS yields inconsistent and biased estimates of the causal effect (Bound *et al.*, 1995). In order to tackle this endogeneity problem we resort to GMM techniques.

In equation (1), if $eGOV_i$ and $INTERNET_{i,t-1}$ are endogenous then $E\left(eGOV_i \cdot \varepsilon_{i,t}\right) \neq 0$ and $E\left(INTERNET_{i,t-1} \cdot \varepsilon_{i,t}\right) \neq 0$. Hence, we need to instrument these two variables. In addition, instead of using real GDP per capita in 1990, $GDPCAP_i$, as done in the OLS estimations above, we instrument current real GDP per capita, $GDPCAP_{i,t-1}$, using $GDPCAP_i$. This improves efficiency.

Define the vector of instruments as $Z'_{i,t-1} = [z_{i1,t-1}, .., z_{iM,t-1} : X_{i,t-1}]$. We require that $E\left(Z_{i,t-1} \cdot \varepsilon_{i,t}\right) = 0$. In our estimations, where $M = 5$, we have that $z_{i1,t-1}, z_{i2,t-1}, z_{i2}.., z_{i5}$

equal the share of the population aged 0 to 14 years, the share of the population residing in urban areas, initial (1990) real GDP per capita, power transmission and distribution losses, and the number of telephone mainlines per 1,000 people, respectively (all taken from WDI, 2004). In particular, the share of the population aged 0 to 14 years and the share of the population residing in urban areas have been found to explain Internet penetration rates by Chinn and Farlie (2004). Power transmission and distribution losses (a proxy for the realiability of the power supply) and the number of telephone mainlines are important determinants of the quality of the infrastructure needed to sustain ICT. These variables explain one-third of the variation in e-government. We test the validity of all instruments below.

Compared to Table 1 the GMM coefficients associated with $INTERNET_{i,t-1}$ and $eGOV_i$ in Table 2 are always higher than the corresponding OLS estimates. This is an indication of endogeneity bias. Note also that all our instruments are valid: in each column in Table 2 the Hansen J statistic, a test for over-identifying restrictions, indicates validity; the tests of excluded instruments indicate strong partial correlations in all first-stage regressions (see Bound *et al.*, 1995).

The salient features of Table 2 is that $INTERNET_{i,t-1}$ enters significantly in all columns. This provides strong empirical support for the existence of an *information channel*. The e-government variable is marginally significant in columns (1) to (4). In columns (5) and (6) $eGOV_i$ is insignificant. However, a F-test of the restriction that three of the four Controls 2 variables (population size, government expenditure and openness) are zero cannot be rejected at significance levels below 0.63 and 0.64 in columns (5) and (6), respectively. When these three variables are excluded (i.e. only women in parliament is retained), $eGOV_i$ enters marginally significant in both columns (not reported). Overall, this provides some support to the existence of an *interface channel* as well.

Table 2: GMM estimates

	(1)	(2)	(3)	(4)	(5)	(6)
INTERNET	0.013***	0.024***	0.010***	0.021***	0.006*	0.028**
	(3.71)	(2.99)	(2.59)	(2.86)	(1.85)	(2.23)
eGOV	1.232*	1.028*	1.337*	1.114**	1.167	0.295
	(1.67)	(1.95)	(1.93)	(1.96)	(1.27)	(0.29)
GDPCAP	0.033	−0.068	0.058***	−0.040	0.058***	−0.140
	(1.17)	(0.63)	(2.83)	(0.42)	(4.30)	(0.99)
PRESS	0.000	0.007	−0.002	0.005	−0.002	0.006
	(0.004)	(0.79)	(0.18)	(0.57)	(0.18)	(0.61)
Controls 1	No	No	Yes	Yes	Yes	Yes
Controls 2	No	No	No	No	Yes	Yes
Excluding OECD	No	Yes	No	Yes	No	Yes
Hansen's J statistic	0.45	1.33	1.30	0.45	1.05	0.63
F(excluded instruments 1)	110.9***	97.1***	33.9***	57.5***	18.0***	21.7***
F(excluded instruments 2)	24.1***	23.3***	23.4***	20.7***	18.3***	14.9***
F(excluded instruments 3)	2534.0***	1726.7***	1481.8***	1275.8***	1772.0***	806.7***
Total observations	494	357	479	348	424	297
No. of countries	101	78	97	75	89	67
R-squared	0.76	0.42	0.83	0.51	0.88	0.34

Dependent variable: Corruption Perception Index (CPI) 1998 - 2003. GMM estimation. We use a cluster-robust optimal weighting matrix: all t-values (reported in parenthesis) are fully robust with respect to arbitrary heteroscedasticity and arbitrary intra-country (intra-cluster) correlation (see Wooldridge, 2002: 193). Asterisks *, **, *** indicate significance at a 10%, 5% and 1% level, respectively. All regressions included a constant term, time and geographical dummies. Controls 1 and Controls 2; see Table 1. Hansen's J statistic, distributed here as $\chi^2(2)$, is a test for overidentifying restrictions (Hayashi, 2000). The test of excluded instruments is a F-test of exclusion of the instruments from the first-stage regressions (see Bound et al., 1995; Staiger and Stock, 1997). Excluded instruments 1, 2 and 3 relates to the INTERNET, eGOV and GDPCAP first-stage regressions, respectively.

Table 3: Fixed effects estimates

	(1)	(2)	(3)	(4)
INTERNET	0.001***	0.001**	0.001***	0.001*
	(3.29)	(2.29)	(3.14)	(1.76)
PRESS			−0.004	0.004
			(0.99)	(1.00)
Excluding OECD	No	Yes	No	Yes
Total observations	588	445	582	439
No. of countries	133	109	132	108
R-squared (within)	0.03	0.05	0.03	0.05

Dependent variable: Corruption Perception Index (CPI) 1998 - 2003. Fixed effects estimation. The test for serial correlation reported in Wooldridge (2002: 275) did not detect any problems. For this reason the variance estimator is only robust with respect to heteroscedasticity (Huber-White corrected). Robust t-values in parenthesis. Asterisks *, **, *** indicate significance at a 10%, 5% and 1% level, respectively. All regressions included time dummies.

Columns (3) and (4) constitute our preferred specifications since they provide a balance between sufficient control variables and sample size considerations. Column (4), where OECD countries have been excluded, is particularly interesting because the two ICT variables, $INTERNET_{i,t-1}$ and $eGOV_i$, have statistical significance at one and five percent, respectively. Hence rich countries do not drive the results. Columns (3) and (4) are also robust with respect to the choice of instrumental variables estimator. The results hold up in a 2SLS setup with fully robust standard errors (not reported) and in a GMM setup with a small sample correction and fully robust standard errors (not reported).[17]

Table 3 reports results from the fixed effects estimator. Note that since both $eGOV_i$ and $GDPCAP_i$ are time-constant variables, they are captured by the country fixed effects. Table 3 shows that the Internet variable is significant in all columns, albeit with a smaller coefficient estimate as compared to Table 2 (due to limited within variation). Note also that

[17] The efficient GMM estimator relies on estimations of fourth moments. Since it takes a larger sample to estimate fourth moments reliably, compared to first or second moments, GMM probably has worse finite sample properties than 2SLS (Hayashi, 2000). It is therefore important that both 2SLS and GMM with small-sample corrections produce similar results as the efficient GMM estimator.

when OECD countries are excluded, as in columns (2) and (4) in Table 3, we still obtain statistical significance at conventional levels. Finally, instrumenting $INTERNET_{i,t-1}$ in the fixed effects estimation (not reported) does not change the conclusions of Table 3.

In the Appendix we also report results using most of the explanatory variables mentioned in Section 2.2. This reduces the sample size considerably. Nevertheless, all conclusions hold up.

Overall, we are led to the conclusion that causation is running from more ICT to less corruption.

4.3 Economic significance

Table 4 reports the standardized (beta) coefficients associated with columns (1), (3) and (5) in Table 2, respectively, provided that estimated coefficients are significant at levels below 10 percent. Inspection of Table 4 reveals that standardized coefficient associated with the Internet variable are located in the range 0.385 to 0.806. Using column (2), a one standard deviation increase in Internet users per $1,000$ people translates into an increase in CPI of roughly 0.58 standard deviation. To see the economic significance of this magnitude consider a country like Vietnam with a CPI score of 2.4 in 2003. In 2002 Vietnam had 18 Internet users per $1,000$ people. If the number of Internet users in Vietnam increased from 18 to 46 (which is the level of China in 2002 and corresponds to a one fifth of a standard deviation increase) our results suggest that the CPI score should increase from 2.4 to approximately 2.7. In 2003 this was equivalent to going from rank 100 to rank 86 in the TI 2003 Corruption Perception Index.

The beta coefficient associated with e-government makes less sense since this is a discrete variable. We need to evaluate going from being without e-government ($eGOV_i = 0$) to having e-government ($eGOV_i = 1$). Carrying out this exercise, i.e. using the estimated coefficient

Table 4: Standardized coefficients

	(1)	(2)	(3)
INTERNET	0.806	0.576	0.385
eGOV	0.230	0.247	
GDPCAP		0.308	0.315

Standardized Coefficients: Columns (1) to (5) are the standardized coefficients associated with columns (1) to (5) in Table 2. The standardized coefficients are calculated as $\hat{b} = \frac{\hat{\sigma_x}}{\hat{\sigma_y}} \times \hat{\beta}$, where $\hat{\sigma_x}$ is the standard deviation of the independent variable, $\hat{\sigma_y}$ is the standard deviation of the dependent variable and $\hat{\beta}$ is the estimated GMM coefficient (see Wooldridge, 2000). We have only estimated standardized coefficients for significant coefficients.

on $eGOV_i$, $\gamma = 1.337$, in column (3), Table 2 and $\Delta eGOV_i = 1$, shows that the CPI score increases by 1.337 CPI points. Continuing the Vietnam counterfactual, going from having no e-government (Vietnam is classified as having no e-government in our sample) to having an "average" level of e-government would move Vietnam from rank 100 to rank 59 in the TI 2003 ranking.

Care must be taken when interpreting these magnitudes. Wilson (2004), for instance, argues convincingly that the diffusion of ICT technologies is dependent upon a myriad of complex factors and interactions. The above exercise do however indicate that the two ICT variables carry substantial economic significance.

5 Concluding Remarks

To our knowledge this paper provides the first attempt at systematically testing the proposition that ICT exerts a causal influence on corruption. Using standard cross-country regression techniques we demonstrate that this proposition is indeed supported by the data.

We have made an attempt at breaking down the causal influence of ICT in an interface channel and an information channel. The former channel turns out to have somewhat less significance, statistical as well as economic, compared to the latter.

The information channel is surprisingly robust and highly significant in all specifications, whether or not instruments are used. At the same time the information channel is rooted in a nascent theoretical literature. Our results should therefore also be seen as a corroboration of the main propositions found in this literature.

We have not been able to find any theoretical work on the interface channel, perhaps because it is so straightforward. Instead we have provided a wave of anecdotal evidence documenting its potential importance. In the OLS framework this channel is insignificant in all specifications. However, as argued in the paper, e-government is in all likelihood endogenous. This is supported by our GMM results, which shows that the interface channel can be given a causal interpretation. The interface channel is less robust than the information channel. This may be due to the fact that the variable capturing this channel is binary and only collected once, in 2001. Consequently, it may have too little variation. Better data are thus needed.

Overall, we acknowledge that results from cross-country regressions should be treated with some care. We do however believe that the results in this paper underscore the huge potential of well-designed ICT policies in the fight against corruption.

Table 5: Appendix

	OLS		2SLS		GMM	
	Coeff	t-statistics	Coeff	t-statistics	Coeff	t-statistics
INTERNET	0.003***	(2.64)	0.015*	(1.70)	0.020**	(2.46)
eGOV	0.290	(0.82)	1.629	(1.17)	1.031	(0.83)
GDPCAP	0.050	(1.29)	0.059*	(1.76)	0.046	(1.40)
PRESS	−0.015	(1.44)	−0.001	(0.07)	−0.001	(0.04)
Women	0.059***	(3.19)	0.047**	(2.01)	0.038	(1.63)
Opennnes	0.001	(0.21)	−0.005	(1.26)	−0.005	(1.40)
Population size (log)	−0.395***	(3.13)	−0.356*	(1.84)	−0.250	(1.35)
Gov. expenditure	0.004	(0.16)	0.013	(0.40)	0.012	(0.39)
Black market premium	0.000	(0.19)	0.000	(0.67)	0.000	(1.03)
Schooling	0.001	(0.13)	−0.012	(1.08)	−0.009	(0.93)
Fuel etc.	0.004	(0.41)	0.001	(0.12)	−0.006	(0.64)
Electoral rule	0.673**	(2.11)	0.940**	(2.56)	0.848**	(2.33)
Democracy	0.125	(0.19)	−0.826	(0.81)	−0.902	(0.90)
Gov. wage	−0.050	(0.59)	−0.069	(0.79)	−0.072	(0.82)
Hansen's J statistic				2.56		
F(excluded instruments 1)				2.0*		
F(excluded instruments 2)				9.3***		
F(excluded instruments 3)				260.2***		
Total observations	319		319		319	
No. of countries	59		59		59	
R-squared	0.91		0.80		0.70	

Dependent variable: Corruption Perception Index (CPI) 1998 - 2003. The table includes the following additional (potential) determinants of corruption: fuels, minerals and metals export share of total merchandise export, the gross secondary school enrollment ratio (all from WDI, 2004); the average black market premium from 1996 to 1999 (from World Bank Global Development Network Database); the average government wage to per capita GDP ratio for the period 1990-2000 (from World Bank Cross-National Data on Government Employment and Wages supplemented with data documented in Treisman, 2000); a dummy for whether a country has been an uninterrupted democracy between 1950 and 1995 (from Treisman, 2000); data on the proportion of legislators in the lower house elected individually or on open lists (from Persson et al., 2003). All regressions include a constant term, time dummies, legal origin dummies, indices of linguistic, religious and ethnic fractionalization, and geographical dummies. Instruments: initial (1990) real GDP per capita, the share of the population aged 0 to 14 years, the fraction of the population residing in urban areas, latitude (from CIA Factbook) and average tourist arrivals (1997-2002) (from WDI, 2004). See Table 2 for additional details.

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